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Indian Standard

GUIDANCE FOR ENVIRONMENTAL TESTING

PART XIII VIBRATION (SINUSOIDAL) TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART XIII VIBRATION (SINUSOIDAL) TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART XIII VIBRATION (SINUSOIDAL) TEST

0. FOREWORD

0.1 This Indian Standard (Part XIII) was adopted by the Indian Standards Institution on 25 September 1981, after the draft finalized by the Environmental Testing Procedures Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard (Part XIII) covers guidance for the vibration (sinusoidal) test. The procedure for the vibration (sinusoidal) test is covered in IS : 9000 (Part VIII)-1981*.

0.3 While preparing this standard, assistance is derived from Doc: 50A (Central Office) 145 'Draft – Revision of IEC Pub 68-2-6 (1970) Test F – Vibration (Sinusoidal)' issued by the International Electrotechnical Commission (IEC).

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part XIII) gives guidance on vibration (sinusoidal) test.

2. OBJECT

2.1 The object of this test is to provide a standard procedure to determine the ability of electronic and electrical items to withstand specified severities of vibration.

3. GENERAL

3.1 The test provides a method by which effects comparable with those likely to be experienced in practice may be simulated in the test laboratory.

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*Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.

†Rules for rounding off numerical values (*revised*).

3.2 The parameters given are standardized and suitable tolerances chosen in order to obtain similar results when a test is run at different locations. The standardization of values also enables components to be grouped into categories corresponding to their ability to withstand certain vibration severities given in this standard.

3.3 In vibration testing, the usual approach in previous specifications had been to search for the resonances and then to undertake an endurance test in which an item is vibrated at resonance frequencies for a prescribed time. Unfortunately, it is difficult to differentiate, by means of a general definition, between resonances which are liable to cause failure in service and those unlikely to cause trouble, even when the item is vibrated for long periods.

3.4 In addition, such testing procedures are quite unrealistic when applied to the majority of modern items. Direct observation is almost impossible in the assessment of vibrational characteristics of any enclosed item, or of modern miniaturized assemblies. Vibration transducer techniques often cannot be applied without altering the mass-stiffness distribution of the assembly. In cases where transducers can be used, success depends entirely on the skill and experience of the test engineer in selecting appropriate points in the assembly for measurement.

3.5 The procedure preferred here, that is, endurance by sweeping, minimizes these difficulties and avoids the necessity of defining significant or damaging or critical resonances. The adoption of this method has been influenced by the need to specify test methods which are as well defined as the present state of environmental testing will allow, and which reduce the dependence upon the skill of the test engineer to a minimum.

3.6 The procedure may, however, in some cases take an inconveniently long time, if the endurance duration is intended to be long enough to ensure a fatigue life comparable to the required service time or unlimited fatigue life at an amplitude of vibration comparable with that experienced in service. Therefore, other methods have been given, including endurance at fixed frequencies, which are either predetermined or found during the response investigation. It is expected that fixed frequency endurance is applicable, if during the vibration response investigation the number of such frequencies in each axis is found to be small and not normally exceeding 4. If the number exceeds 4, endurance by sweeping may be more appropriate. Endurance at fixed frequencies still requires a certain amount of engineering judgement in application.

3.7 It may be appropriate to carry out endurance testing both by sweeping and at fixed frequencies. The endurance by sweeping is given by the number of sweep cycles which are derived from related numbers of stress reversals.

3.8 The fixed frequency endurance is given as time in the case of critical frequencies. For any predetermined frequency, the endurance needs to be given in the relevant specification. This time is often based on anticipated number of stress reversals. Due to the wide variety of materials, it is obvious that no realistic single figure could be given for the number of stress reversals. Nevertheless, it is considered that 10^7 is a sufficiently practicable upper figure to be quoted for a general vibration testing and need not be exceeded [*see* **6.3.2.1** and **6.3.2.2** of IS : 9000 (Part VIII)-1981*].

3.9 If it is known that the real environment essentially involves random vibration, a random vibration test shall be used for the endurance phase wherever economically possible. This is particularly applicable in the case of equipment. For some component type items of simple construction a sinusoidal test is usually adequate. The random vibration test shall be introduced in the future standards.

4. MEASUREMENT AND CONTROL

4.1 Control Points — Two main types of control points are defined in **2** of IS : 9000 (Part VIII)-1981*. However, during development it may be necessary to measure local responses within an item in order to establish that the vibration at these points is not likely to cause damage. Under certain circumstances, it may even be necessary to incorporate the signals from such control points into the control loop in order to avoid costly degradation of the item. It shall be noted that this technique is not recommended in this standard as it cannot be standardized [*see* **2.2** of IS : 9000 (Part VIII)-1981*].

4.2 Errors Caused by Distortion — In cases where distortion is high, the measuring system will indicate a vibration level which is incorrect since it contains the required frequency and many unwanted frequencies. This may result in a lower amplitude at the required frequency than is specified. Up to the distortion value specified in **5.1.3** of IS : 9000 (Part VIII)-1981*, this error can be tolerated. However, above this value it may be necessary to restore the level of the fundamental to its required amplitude. There are a number of ways of doing this, but it is recommended that a tracking filter be used. If the level of the fundamental is restored, the item will be subjected to the intended stress at the required frequency. However, the unwanted frequencies will also increase and, as a result, some additional stresses will be caused. If this gives rise to unrealistically high stresses, it may be more appropriate to waive the distortion level requirement by agreement between the customer and the supplier.

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4.3 Derivation of Reference Signal — A number of methods are available for derivation of the reference signal.

If an averaged multipoint reference signal is specified, that is, one derived from the arithmetic mean, one method is to obtain the averaged signal by processing the dc voltages proportional to the peak acceleration levels at each check point.

If a sampled data system is utilized, a sampling frequency equal to the driving frequency may be used. There are, however, problems where such a system is used in conjunction with a tracking filter and due care shall be taken under these circumstances.

The sampled data system may cause problems when the test is to be controlled to a constant displacement amplitude, since the acceleration signal which is integrated twice may not be proportional to the displacement amplitude due to the distortion caused by the phase difference between the sampled signals [*see* **2.9** of IS : 9000 (Part VIII)-1981*].

It is important that the complete vibration system has a low residual noise level, so that most of the tolerance quoted is available during the test [*see* **5.1.4**(a) of IS : 9000 (Part VIII)-1981*].

5. TESTING PROCEDURES

5.1 Vibration Response Investigation — Vibration response investigations [*see* **9.1** of IS : 9000 (Part VIII)-1981*] are most useful when sufficient information is available concerning the operational environment. These investigations are justifiable when it is known that the item will experience considerable vibration of a periodic nature such as is found in ships, propeller driven aircraft, and rotating machinery. The response investigation is also of use, however, when it is considered important to investigate the dynamic behaviour of the item. It may also be appropriate for items whose fatigue is to be assessed.

The use of a vibration response investigation applied before and after the endurance test may be made to identify changes in the frequency at which resonance or some other response occurs. A change in frequency may indicate that some fatigue has occurred and the item may, therefore, be unsuitable for the operational environment.

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*Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.

When prescribing the vibration response investigation, the relevant specification should clearly state: where appropriate, the actions to be taken during and following the test, for example, any special values of dynamic magnification which, if exceeded, should result in endurance by sweeping, changes in frequency or levels of response which are acceptable, electrical noise, etc.

It is important that any arrangements made to detect the effect upon internal parts during a vibration response investigation shall not substantially change the dynamic behaviour of the item as a whole.

When a vibration response investigation is called for in the relevant specification, the availability of any isolators used is of fundamental importance.

If the isolators are available, a first investigation is often carried out with the isolators removed or blocked in order to determine the critical frequencies of the item. A second stage may then also be performed in which the investigation is repeated with the isolators mounted and free, so that the effects which they introduce can be determined. At the two stages, different vibration amplitudes may be needed to take into account the transmissibility characteristics of the isolators.

If the isolators are not available, *see* **7.1**.

5.2 Endurance [*see* **9.2 of IS : 9000 (Part VIII)-1981***] — Endurance by sweeping is the most appropriate method for simulating the effect of the stresses undergone by items in use [*see* **9.2.1** of IS : 9000 (Part VIII)-1981*].

Endurance at fixed frequencies is appropriate to a limited range of items whose operational sites are influenced by machinery or whose installations are restricted to one or a few types of vehicle or aircraft. In these cases, the dominant frequencies are usually known or can be predicted. It may also be appropriate for the rapid accumulation of stress reversals in order to demonstrate the effects of fatigue, for example, arising from excitation during a mobile transportation environment [*see* **9.2.2** of IS : 9000 (Part VIII)-1981*].

In some cases, it may be important to consider possible fatigue aspects at some discrete frequencies as well as to establish the general ability of an item to withstand vibration. Under these circumstances, it would be appropriate to carry out endurance at fixed frequencies followed by endurance by sweeping. This would then provide the information required in the shortest possible time.

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*Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.

In the case of small components, where there is confidence that no resonances exist below 55 or 100 Hz, it is sufficient to commence the endurance at these frequencies.

During endurance testing of an equipment normally mounted on isolators it is usually tested with the isolators fitted. If it is not practicable to carry this out with the appropriate isolators, for example, if the equipment is installed together with other equipment on a common mounting device, the equipment may be tested without the isolators at a different severity as stated in the relevant specification. This amplitude shall be determined by taking into account the transmissibility of the isolating system in each axis used for the test. When the characteristics of the isolators are not known, *see* **7.1**.

The relevant specification may require an additional test on an item with the external isolators removed or blocked in order to demonstrate that minimum acceptable structural resistance has been achieved. In this case, the severity to be applied shall be given in the relevant specification.

6. TEST SEVERITIES

6.1 Selection of Test Severities for Equipment — The frequencies and amplitudes given have been selected to envelop the frequency responses appropriate to a wide range of applications. When an item is for use in one application only, it is preferable to base the severity on the vibration characteristics of the actual environment, if known. When the vibration conditions of the actual environment are not known for an equipment, the appropriate test severity shall be selected from Appendix A which gives examples of test severities related to various applications.

As the value of displacement amplitude is associated with a corresponding value of acceleration amplitude in such a manner that the magnitude of vibration is the same at the cross-over frequency, the frequency range may be swept continuously, changing from constant displacement to constant acceleration and *vice versa* at the cross-over frequency. Cross-over frequencies between 8 and 9 Hz and between 57 and 62 Hz are given. Cross-over frequencies other than the standard ones may be required where it is desirable to simulate the actual environment, if known. If this results in a high cross-over frequency, the capability of the vibration generator shall be borne in mind. It is important that the displacement amplitude chosen does not correspond to an acceleration amplitude in the low frequency region comparable to the residual noise level of the vibration system [*see* **6.2** of IS : 9000 (Part VIII)-1981*].

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*Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.

6.2 Selection of Test Severities for Components — The selection of test severities for components is complicated by the fact that in many cases it is not known in which equipment they are to be installed nor the environment to which it will be subjected. Even in cases where it is known that components are for use in specific items of equipment, it shall be borne in mind that the vibration environment to which the component shall be subjected may be different to that where the equipment shall be subjected due to the dynamic response of its structure, sub-assemblies, etc.

Caution should, therefore, be observed in selecting component test severities related to equipment severities and some margin may need to be allowed for the effect of these responses.

Where components are mounted in the equipment in a manner designed to protect them from vibration, the equipment test severities or possibly a lower severity may be appropriate.

An alternative approach to the selection of component test severities may be to grade and test components to a stated severity, so that equipment designers may select components appropriate to their application.

Reference should be made to Appendix B which gives examples of severities related to various applications.

6.3 Sweep — During sweeping, the frequency is required to change exponentially with time, so that:

$$\frac{f}{f_1} = e^{kt}$$

where

f = frequency,
f_1 = lower frequency limit of the sweep,
k = a factor depending on sweep rate, and
t = time.

For this test the sweep rate is 1 octave/minute and thus $k = \log_e 2 = 0{\cdot}693$, if the time is expressed in minutes [*see* **5.1.8** of IS : 9000 (Part VIII)-1981*].

In order to establish the number of octaves for a sweep cycle, the following formula applies:

$$N = 2 \log_2 \left(\frac{f_2}{f_1}\right) = \frac{2}{\log_{10} 2} \log_{10} \left(\frac{f_2}{f_1}\right) = 6{\cdot}644 \log_{10} \left(\frac{f_2}{f_1}\right)$$

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where

N = number of octaves,
f_1 = lower frequency limit of the sweep, and
f_2 = upper frequency limit of the sweep.

Values derived utilizing the above formula are given in Table 1 and show the rounded times associated with the recommended numbers of sweep cycles and frequency ranges [*see* **6.3.1** of IS : 9000 (Part VIII)-1981*].

7. EQUIPMENT NORMALLY USED WITH VIBRATION ISOLATORS

7.1 Transmissibility Factors for Isolators — When an item would normally be mounted on isolators, but they are not available and their characteristics are unknown, it is necessary to modify the specified level in such a way as to provide a more realistic vibration input to the item. Under such circumstances, it is recommended that this modified level be derived by using values taken from the curves given in Fig. 1 and described below.

a) Curve *A* relates to a type of loaded isolator of high resilience having a natural frequency, when considering a single degree of freedom, not exceeding 10 Hz.

b) Curve *B* relates to a type of loaded isolator of medium resilience having a natural frequency, as qualified above, in the range of 10 to 20 Hz.

c) Curve *C* relates to a type of loaded isolator of low resilience having a natural frequency, as qualified above, in the range of 20 to 35 Hz.

Curve *B* is derived from vibration measurements made on typical aircraft equipment fitted with highly damped all-metal mountings having a natural frequency of approximately 15 Hz, considering a single degree of freedom.

Very little data were available for isolators represented by Curves *A* and *C* which were derived by extrapolation from Curve *B*, considering natural frequencies of 8 Hz and 25 Hz respectively.

The transmissibility curves have been estimated to envelop the transmissibility characteristics likely to arise in an installation in which modes are coupled. The use of these curves, therefore, makes an allowance for the vibration levels arising at the periphery of an item from the combined effects of translatory and rotational motions.

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TABLE 1 NUMBER OF SWEEP CYCLES AND ASSOCIATED ENDURANCE TIMES PER AXIS

(*Clause* 6.3)

SL No.	FREQUENCY RANGE Hz	NUMBER OF SWEEP CYCLES						
		1	2	5	10	20	50	100
1.	1-35	10 min	21 min	50 min	1 h 45 min	3 h 30 min	9 h	17 h
2.	1-100	13 min	27 min	1 h 5 min	2 h 15 min	4 h 30 min	11 h	22 h
3.	5-35	6 min	11 min	30 min	1 h	2 h	4 h 45 min	9 h 30 min
4.	5-150	10 min	20 min	50 min	1 h 45 min	3 h 15 min	8 h	16 h
5.	5-350	12 min	25 min	1 h	2 h	4 h	10 h	20 h
6.	5-500	13 min	27 min	1 h 5 min	2 h 15 min	4 h 30 min	11 h	22 h
7.	5-2 000	17 min	35 min	1 h 30 min	3 h	5 h 45 min	14 h 30 min	29 h
8.	7-300	11 min	22 min	55 min	1 h 50 min	3 h 45 min	9 h	18 h
9.	10-55	5 min	10 min	25 min	45 min	1 h 45 min	4 h	8 h
10.	10-150	8 min	16 min	40 min	1 h 15 min	2 h 30 min	7 h	13 h
11.	10-500	11 min	23 min	55 min	2 h	3 h 45 min	9 h	19 h
12.	10-2 000	15 min	31 min	1 h 15 min	2 h 30 min	5 h	13 h	25 h
13.	10-5 000	18 min	36 min	1 h 30 min	3 h	6 h	15 h	30 h
14.	55-500	6 min	13 min	30 min	1 h	2 h	5 h	11 h
15.	55-2 000	10 min	21 min	50 min	1 h 45 min	3 h 30 min	9 h	17 h
16.	55-5 000	13 min	26 min	1 h 5 min	2 h 15 min	4 h 15 min	11 h	22 h
17.	100-2 000	9 min	17 min	45 min	1 h 30 min	3 h	7 h	14 h

NOTE 1 — The endurance times given in the table have been calculated for a sweep rate of 1 octave/minute and are rounded up or down. The error caused by this in no case exceeds 10 percent.

NOTE 2 — The figures underlined have been taken from Appendices A and B.

The most appropriate transmissibility curve shall be selected and the specified vibration levels shall be multiplied by values taken from this curve over the required frequency range. The product of values taken from these two curves may result in test levels which test engineers might find impossible to reproduce in the laboratory. In this case, the test engineer should adjust the levels in such a way that the maximum possible level is achieved at all times throughout the complete frequency range. It is of the utmost importance that the actual values used are recorded.

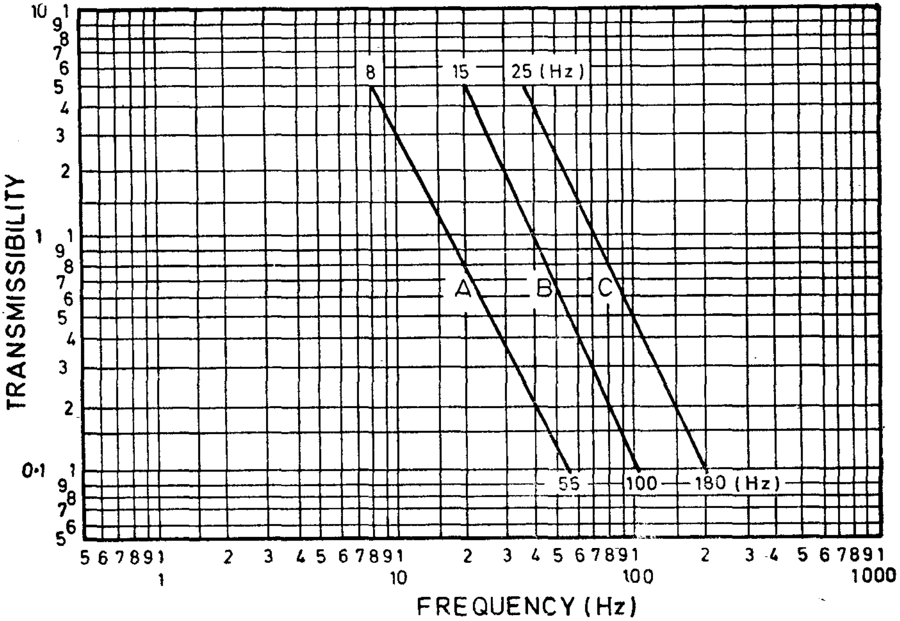

FIG. 1 GENERALIZED TRANSMISSIBILITY CURVES FOR LOADED ISOLATORS

7.2 Temperature Effect — It is important to note that many isolators contain material which is temperature dependent. If the fundamental resonance frequency of the item on the isolators is within the test frequency range, caution shall be exercised in deciding the length of time for which any endurance should be applied. If the actual time distribution of excitation of this fundamental resonance frequency is known, an attempt should be made to simulate it. However, under some circumstances it may be unreasonable to apply continuous excitation without permitting recovery. If the actual time distribution is not known, excessive over-heating shall be avoided by limiting the periods in a manner which will require engineering judgement, taking into account **6.3** of IS : 9000 (Part VIII)-1981*.

8. DURATION

8.1 Basic Concept [see 6.3 of IS : 9000 (Part VIII)-1981*] — Many exciting specifications describe the endurance phase of a vibration test in terms of time duration. This makes it virtually impossible to correlate the behaviour of one resonant item with another if their frequency ranges are dissimilar, since the resonances will be excited for a different number of times. For instance, it is often considered that, for a given acceleration value and endurance time, the test is more severe with a wide frequency range than with a narrow one. However, this is not the case. The concept of the number of sweep cycles as an endurance parameter overcomes this problem, since the resonance will be excited for the same number of times irrespective of the frequency range.

Examples of severities for equipment and components are given in Appendices A and B.

8.2 Tests — Where the test is simply to demonstrate the ability of an item to survive and/or operate at appropriate amplitudes, the test need only continue for a duration sufficient to demonstrate this requirement over the specified frequency range. In cases where the ability of an item to withstand the cumulative effects of vibration is to be demonstrated, for example, fatigue and mechanical deformation, the test shall be of a sufficient duration to accumulate the necessary stress cycles. For demonstration of unlimited fatigue life a total of 10^7 reversals of stress is normally considered adequate.

9. DYNAMIC RESPONSE

9.1 A major cause of damage is the dynamic stresses produced within the test item. The classic example is the stress produced within a simple mass/spring system when the system is attached to a vibrating body whose, inertia is large in relation to that of the mass. At the frequency of resonance, the spring mass responds with an increase in amplitude of motion inducing increased stress in the spring. The performance of an endurance test at such a resonance frequency requires a great deal of engineering judgement. The difficulty lies mainly in determining which resonances are significant. An additional problem might be that of maintaining the driving frequency at resonance.

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9.2 At higher frequencies particularly, the resonances may not be very apparent, but nevertheless high stress levels may occur locally. Whilst some specifications attempt to define the severity of a resonance by an arbitrary value for the dynamic magnification, this method has not been adopted for this test.

9.3 The procedures given in this test imply that the vibration amplitude (displacement or acceleration) shall be kept to a prescribed value independent of the dynamic reaction of the item. This is in accordance with the state-of-art of vibration testing of a general kind suitable for standardization.

9.4 It is important to remember that in the case of a non-linear resonance, an item may respond differently depending upon the direction of the frequency variation during the sweep.

9.5 It is well known that when an item is excited at its resonance frequency, its apparent mass may be high in relation to its operational mounting structure. In such a case, the reaction of the item may be considerable. The driving force and the mechanical impedance of the structure are normally not known and general assumptions regarding these parameters are usually extremely difficult to make.

9.6 Force control is foreseen as a means of reducing the above problem but is not included in the test, since it is not possible at present to give information on procedures, measurements and tolerances. When such a test is called for by the relevant specification, it is possible either to use force transducers or to rely on a measurement of the driving current. The latter procedure has certain drawbacks, since the current may not be proportional to the force over parts of the frequency range specified for the test. Nevertheless, with good engineering judgement, the method utilizing current measurement may be used, particularly if a limited frequency range is involved.

9.7 Thus, whilst a force controlled test may appear to be attractive, caution shall be exercised in its use. Certainly in some cases, for example, components, the amplitude-controlled test is almost always more appropriate [*see* **9** of IS : 9000 (Part VIII)-1981*].

10. PERFORMANCE EVALUATION

10.1 Items shall be operated either throughout the test or at appropriate phases of the test, in a manner representative of their required functioning conditions. At suitable intervals throughout the endurance phase, and towards the end of it, functional checks of the items are recommended.

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10.2 For items in which vibration may influence the switch-on and off function (for example, interfering with the operation of a relay), such functioning shall be repeated to demonstrate a satisfactory performance in this respect, either over the frequency range of the test, or at those frequencies likely to cause interference.

10.3 If the test is to demonstrate survival only, the functional performance of items shall be assessed after the completion of vibration endurance [*see* **9.2** of IS : 9000 (Part VIII)-1981*].

11. INITIAL AND FINAL MEASUREMENTS

11.1 The purpose of initial and final measurements is to compare particular parameters in order to assess the effect of vibration on the item.

Apart from visual examination, the measurements may include electrical and/or mechanical operational characteristics, dimensions, etc [*see* **8** and **12** of IS : 9000 (Part VIII)-1981*].

APPENDIX A

(*Clauses* 6.1 *and* 8.1, and *Table* 1)

EXAMPLES OF SEVERITIES PRIMARILY INTENDED FOR EQUIPMENT (FOR GUIDANCE ONLY)

A-1. EXAMPLES OF SEVERITIES

A-1.1 When the actual vibration severity is known, it should be used (*see* **6.1**). When the severity is not known, it is necessary to make an arbitrary choice, but one which is based, as far as possible, on similar generalized severities for related applications as given in this Appendix.

A-1.2 Several combinations of frequency range, vibration amplitude and endurance duration are given as examples of severities primarily intended for the testing of equipment, and other articles (*see* Tables 2 and 3). These severities have been selected from the recommended parameters for endurance stated in **6** of IS : 9000 (Part VIII)-1981* and they are considered to cover the more common applications of the vibration test. No attempt has been made to produce an exhaustive list and requirements not covered by this Appendix shall be chosen from the other recommended severities given in this standard and shall be prescribed in the relevant specification.

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*Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.

A-1.2.1 Examples of certain additional severities primarily intended for equipment are given in Table 4.

A-1.3 In certain applications, it may not be practicable to use endurance by sweeping and it may be necessary to carry out tests at critical frequencies. Such tests shall be prescribed by the relevant specification in accordance with the appropriate clauses of this standard.

A-2. ENDURANCE

A-2.1 Endurance by Sweeping — The examples are given in Tables 2 and 3.

A-2.2 Endurance at Critical Frequencies — The typical durations for the endurance at each critical frequency in each axis are 10 minutes, 30 minutes and 10 hours.

TABLE 2 EXAMPLES OF SEVERITIES PRIMARILY INTENDED FOR EQUIPMENT, SELECTED FROM FIG. 2 (CONSTANT ACCELERATION)

(*Clauses* A-1.2 *and* A-2.1)

Endurance by Sweeping	Number of Sweep Cycles in Each Axis			Examples of Application*
Frrquency / Acceleration Range Hz	$0 \cdot 5 g_n$	$1\ g_n$	$2\ g_n$	
10-150	50	—	—	Stationary equipment such as equipment installed in rolling mills, long-term exposure
10-150	20	—	—	Stationary equipment such as large transmitters and air conditioners, intermittent exposure
10-150	—	20	20	Equipment intended for installation in or transport by ships, railway and land vehicles

*These examples do not restrict the use of equipment to the applications mentioned herein. The selection of severities shall be based on particular application for which the equipment is intended.

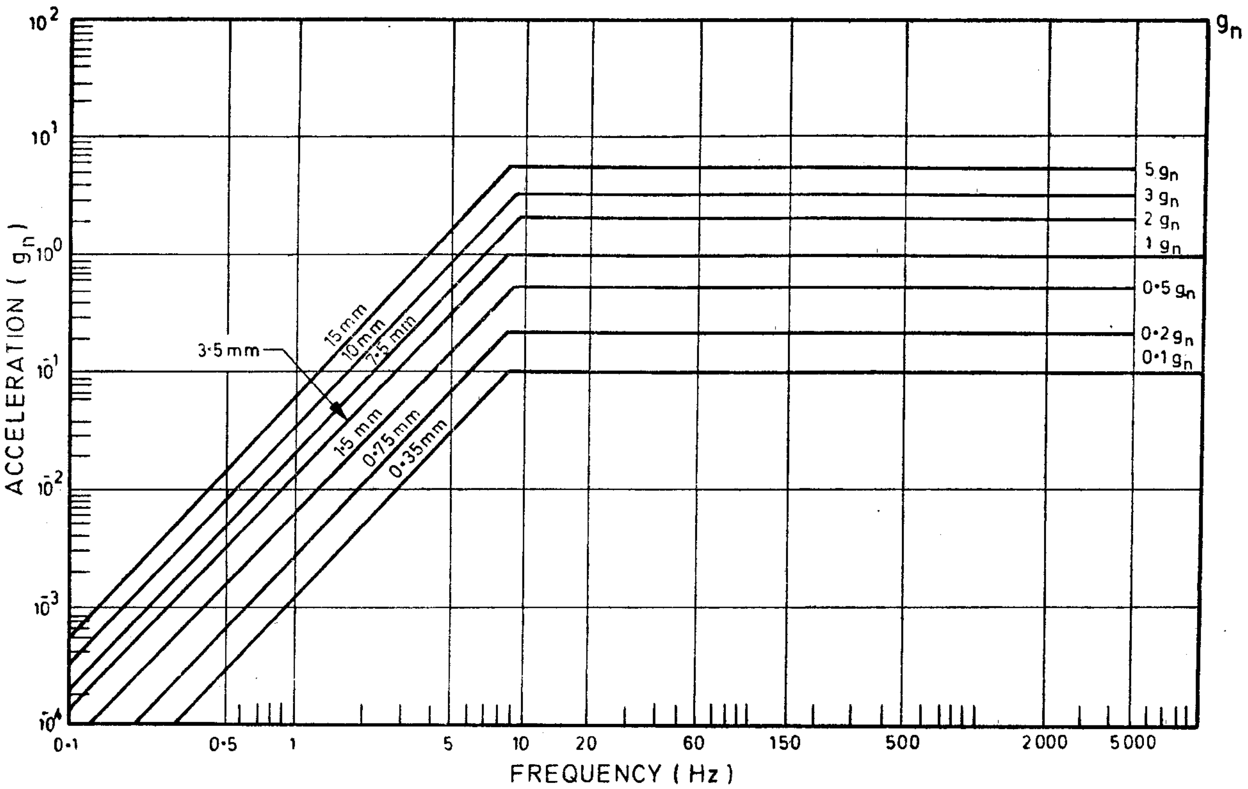

FIG. 2 VIBRATION AMPLITUDE WITH LOWER CROSSOVER FREQUENCY, 8 TO 9 Hz

TABLE 3 EXAMPLES OF SEVERITIES PRIMARILY INTENDED FOR EQUIPMENT, SELECTED FROM FIG. 3 (HIGH CROSSOVER FREQUENCY 57-62 Hz)

(*Clauses* A-1.2 *and* A-2.1)

ENDURANCE BY SWEEPING	NUMBER OF SWEEP CYCLES IN EACH AXIS				EXAMPLES OF APPLICATION†
FREQUENCY RANGE Hz / AMPLITUDE*	0·15 mm or 2 g_n	0·35 mm or 5 g_n	0·75 mm or 10 g_n	1·5 mm or 20 g_n	
1-35‡	—	100	100	—	Equipment mounted adjacent to heavy rotating machinery
10-55‡	10	—	—	—	Equipment intended for large power plants and for general industrial use
	20	20	—	—	
	100	—	—	—	
10-150	10	—	—	—	Equipment intended for large power plants and for general industrial use, where it has been found that appreciable vibration of components exists beyond 55 Hz
	20	20	—	—	
	100	—	—	—	
10-500	10	10	—	—	Equipment for general aircraft use, the higher values apply to equipment close to, but not within, the engine compartment
10-2 000	—	10	10	—	Equipment for high-speed aircraft, the higher values apply to equipment close to, but not within, the engine compartment
10-2 000	—	—	—	10	Aircraft engine compartments

*Displacement amplitude below the crossover frequency and acceleration amplitude above the crossover frequency, 57-62 Hz [*see* **6.2** and Table 5 of IS : 9000 (Part VIII)-1981§].

†These examples do not restrict the use of equipment to the applications mentioned herein. The selection of severities shall be based on particular application for which the equipment is intended.

‡Constant displacement amplitude test.

§Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.

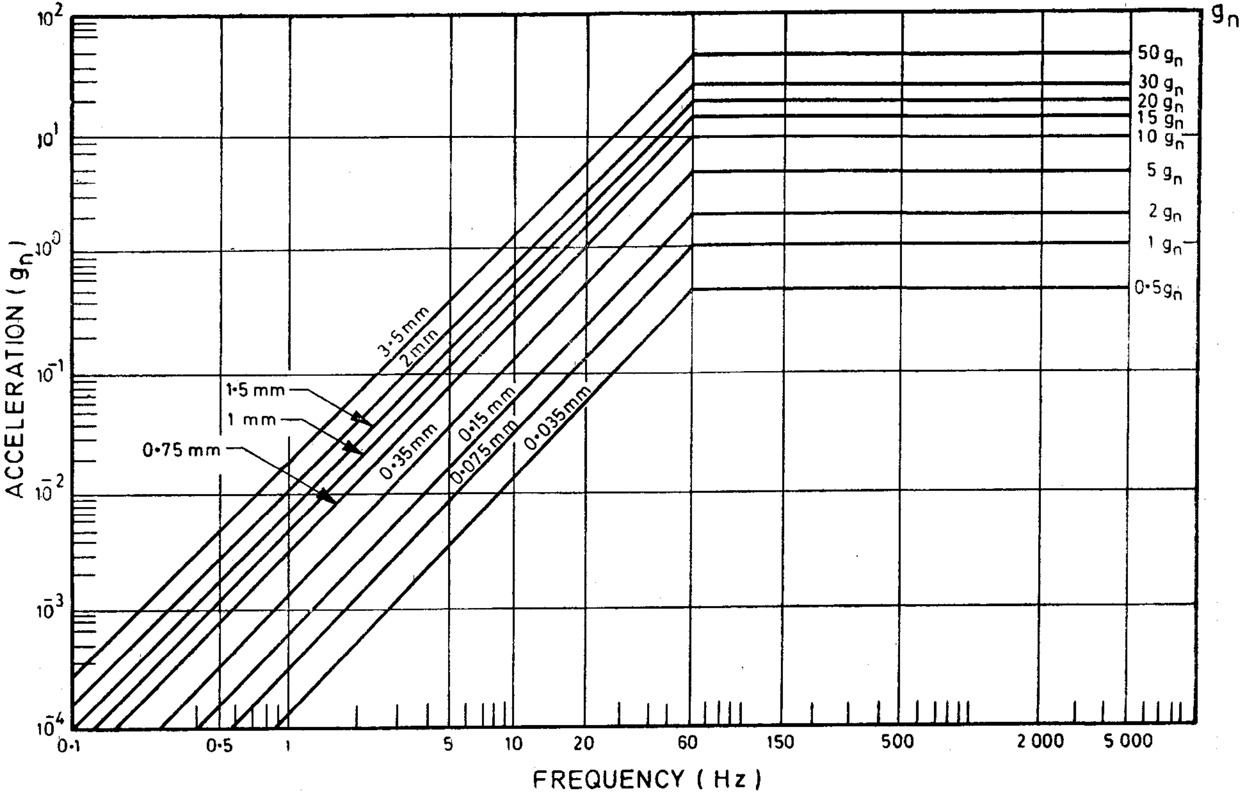

FIG. 3 VIBRATION AMPLITUDE WITH HIGHER CROSSOVER FREQUENCY, 57 TO 62 Hz

TABLE 4 EXAMPLES OF ADDITIONAL SEVERITIES PRIMARILY INTENDED FOR EQUIPMENT

(*Clause* A-1.2.1)

Frequency Range Hz		Amplitude	Examples of Application*
5-500			Ground equipment installed in tracked vehicles (Level 1)
	5-13	6 mm	
	13-500	4 g_n	
5-2 000			Ground equipment installed in tracked vehicles (Level 2)
	5-13	6 mm	
	13-142	4 g_n	
	142-201	0·05 mm	
	201-2 000	8 g_n	
5-500			Equipment installed in wheeled vehicles and trailers
	5-8	6 mm	
	8-500	1·5 g_n	
5-350		6 mm or 2 g_n, whichever is lesser	Equipment transported by vehicle, ship or aircraft and weighing up to 75 kg
5-150 (*see* Note)		do	Equipment transported by vehicle, ship or aircraft and weighing over 75 kg
5-35			Equipment installed in the masthead region of major warships
	5-14	1·25 mm	
	4-23	0·45 mm	
	23-35	0·125 mm	
5-35			Equipment installed in after region of major warships
	5-23	0·45 mm	
	23-33	0·125 mm	
5-35		0·125 mm	Equipment installed in main region of major warships
7-300		0·4 mm or 60 mm/s, whichever is less	Equipment installed in after region of minor warships
7-300		0·2 mm or 30 mm/s, whichever is less	Equipment installed in main region of minor warships
5-35		0·125 mm	Equipment installed in submarines

NOTE — If the equipment has a designated base, the vibration conditions shall be applied in only one plane normal to the base.

*These examples do not restrict the use of equipment to the applications mentioned herein. The selection of severities shall be based on particular application for which the equipment is intended.

APPENDIX B

(*Clauses* 6.2 *and* 8.1, and *Table* 1)

EXAMPLES OF SEVERITIES PRIMARILY INTENDED FOR COMPONENTS (FOR GUIDANCE ONLY)

B-0. GENERAL

B-0.1 The possible number of severities allowed by **6** of IS : 9000 (Part VIII)-1981* is very large. To simplify the application of this standard, examples of severities primarily intended for components have been selected from the recommended parameters for endurance stated in **6** of IS : 9000 (Part VIII)-1981* and are given in this Appendix. The conditions for testing are as prescribed in this standard.

B-1. ENDURANCE

B-1.1 Endurance by Sweeping — The examples are given in Table 5.

B-1.2 Endurance at Critical Frequencies — The typical durations for the endurance at each critical frequency in each axis are 10 minutes 30 minutes, and 10 hours.

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*Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.

TABLE 5 EXAMPLES OF SEVERITIES FOR COMPONENTS

(*Clause* B-1.1)

ENDURANCE BY SWEEPING	NUMBER OF SWEEP CYCLES IN EACH AXIS						EXAMPLES OF APPLICATION†
FREQUENCY / AMPLITUDE* RANGE Hz	0·35 mm or 5 g_n	0·75 mm or 10 g_n	0·75 mm or 15 g_n	0·75 mm or 20 g_n	0·75 mm or 50 g_n	1·5 mm or 20 g_n	For use in equipment intended for installation in:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
10-55	10	10	—	—	—	—	Large industrial power plant, heavy rotating machinery, steel rolling mills, large merchant and naval ships
	—	24	—	—	—	—	
10-500	10	10	—	—	—	—	General purpose land-based and land transport, fast small marine craft (naval or civil) and general aircraft
	—	16	—	—	—	—	
10-2 000	—	10	—	—	—	10	Space launchers (20g_n). Engine-mounted components in aircraft
	—	12	16	16	16	—	
55-500	10	10	—	—	—	—	Application for 10-500 Hz but applicable to small rigid components with no resonance response at frequencies below 55 Hz
55-2 000	—	10	—	—	—	10	Application for 10-2 000 Hz, but applicable to small rigid components with no resonance response at frequencies below 55 Hz
100-2 000	—	10	—	—	—	10	Application for 55-2 000 Hz, but applicable to very small components of very rigid construction, for example, encapsulated transistors, diodes, resistors and capacitors

*Displacement amplitude below the crossover frequency and acceleration amplitude above the crossover frequency. The crossover frequencies are between 57 and 62 Hz [*see* **6.2** and Table 5 of IS : 9000 (Part VIII)-1981‡].

†These examples do not restrict the use of component to the applications mentioned herein. The selection of severities shall be based on particular application for which the component is intended.

‡Basic environmental testing procedures for electronic and electrical items: Part VIII Vibration (sinusoidal) test.